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CONTENTS:

THE RECENT NEWS from the Equatorial Province shows that the Mahdi's successor, Abdullah, has as strong a hold upon the Mohammedan peoples of Egyptian Sudan as had his predecessor. While for some time the impression prevailed that the fanaticism of these tribes had abated, the attacks upon the English at Suakin proved at least that the Mahdi still swayed over the region from Khartum to Berber. It will be remembered that since the unexplained retreat of the Mahdi from the Equatorial Province Emin Pacha had been comparatively undisturbed, but about the end of last year rumors of a renewed attack reached the coast. It was stated that in March the Mahdi contemplated sending four thousand men on four of Gordon's old steamboats up the Nile, in order to attack Emin. If Osman Digma's message to the English be true, and not a trap, this expedition has been successful, and Emin has at last succumbed to the powerful religious movement which centres in Khartum, and with him Stanley, who had joined hands with him since November last year; and both would share the fate of the unfortunate Lupton and Slatin. It is said that a derwish named Omar Saleh returned some months ago from a successful raid into the upper valley of the White Nile. He seems to have encountered Emin in October at Lado, and captured him and Stanley. Undoubtedly Emin would not have been able to withstand the attack of an expedition like the one referred to, and from his former behavior it does not appear probable that he would have retreated south-eastward. While the news is quite probable and credible, we may still maintain a faint hope that it has been merely invented to prevent the English from energetic action at Suakin. It has been stated before that the only real means of helping Emin would have been an attack upon the Mahdi from the north; but this, of course, was out of the question, since the English had given up the Sudan. Stanley's expedition was a failure, as, on account of his long delay and the destruction of his rear guard, he was unable to supply Emin with a sufficient amount of ammunition and trustworthy men. Neither would the planned German expedition have been of great account in a war with the Mahdi, as it would hardly have succeeded in opening a route to Emin, which latter would have been the only means of maintaining the rule over the Equatorial Province.

THE SELECT COMMITTEE of the Senate of the Dominion of Canada, appointed to inquire into the resources of the great Mackenzie basin, has collected a vast amount of information, which has recently been published, and of which we give abstracts in another place. Although much of the information contained in this report is too vague to be of value, the greater part is founded on sound reports of well-informed men, and our knowledge of the natural productiveness of this vast area is greatly increased. In weighing the economic value of the area under discussion, it must be considered that the northern limit of vegetable products and of pastureland does not coincide with the northern limit of profitable agriculture and stock-raising. In the report of the committee, the analogy of those parts of Russia near the northern limit of possible agriculture is frequently emphasized; but it must be borne in mind that the economic conditions of America and Russia are fundamentally different. Up to this time, agriculture in the new West is founded on extensive culture, no attempt being made to make the soil yield the largest possible continuous returns by intensive culture. At the same time a great portion of the immigrants do not settle there to make a living, but with the prospect of becoming wealthy. In Canada as well as in the United States a great number of settlers in the prairie territory are at the same time land-speculators. For these reasons the limit of agriculture will not approach as closely the limit of possible agriculture as it does in Russia, where a native population, loving the native soil, makes a hardy living. It is only when the economic conditions of the Western States shall have undergone a complete change that these northern districts, which are able to support a population, will become settled.

TERIA.[1]

AS director of the Hoagland Laboratory, I take advantage of this opportunity to congratulate Dr. Hoagland, the city of Brooklyn, and my present audience, upon the completion of this building, devoted exclusively to scientific research, and instruction in certain departments of biology; viz., in physiology, pathology, histology, and bacteriology. Indeed, I may extend my congratulations much further; for such a laboratory as this is a centre from which the rays of scientific learning will radiate to all parts of this great country, and which cannot fail to exercise an important influence upon the progress of knowledge in these fields of research. I do not know when Dr. Hoagland first conceived the idea of building and equipping a laboratory devoted to these fundamental branches of medical science, but it is now nearly two years since he made his first visit to Baltimore for the purpose of inspecting the laborato-

[1] Portion of a lecture delivered by Dr. George M. Sternberg at the Hoagland Laboratory, Brooklyn, Nov. 17, 1888.

ries connected with Johns Hopkins University. These had been recently built under the direction of professors familiar with the best laboratories of Europe, and Dr. Hoagland could not have found in Great Britain or on the continent any better models from which to make his plans. We are indebted to him not only for the money required to build and equip such a laboratory as this, but for his constant personal supervision and attention to details, from the first draughts of the plan until the moment of completion. I have been consulted from time to time; and the first visit to Baltimore was followed by several others, in which Dr. Hoagland carefully noted all of those minor details which go to make a laboratory complete and comfortable. The result is, as you see, a building thoroughly suited to the purpose for which it was designed, and which also, from an architectural point of view, is an ornament to the "City of Churches."

I have also been consulted with reference to apparatus; and we have here to-day, or on the way from Europe, every thing that occurred to me as essential for the equipment of the laboratory. The library has also been most generously provided for, and it is the intention to have upon its shelves not only standard books of reference, but, so far as possible, complete files of the English, French, and German periodicals relating to those branches of research to which the laboratory is devoted.

No one appreciates the advantages of such a laboratory as this more than I do, and I would be happy if circumstances made it possible for me to go into camp here during the balance of my working life. A pioneer in this country in the pursuit of bacteriological studies, I have seen to open up before me a most inviting field of research, presenting a multitude of important questions awaiting solution by the experimental method, and I have learned by experience how little can be accomplished in the absence of suitable laboratory facilities.

I have felt from the first that this country ought to take some part in the investigations relating to the etiology of infectious diseases, which have resulted, within the brief period of twenty years, in discoveries which will make this the most famous epoch in the history of scientific medicine. There can be no question that we have plenty of men who have the necessary intelligence and zeal to make them leaders in this or any other department of scientific investigation, but we have sadly lacked just those facilities which are furnished by this laboratory; for intelligence and zeal cannot take the place of training and a knowledge of the methods of research which have been perfected by the patient labors of others. The young man who starts out to make discoveries without such training is like the old farmer, who, after churning for years with an old-fashioned up-and-down, dash-churn suddenly conceives the idea that a churn with a crank would be an improvement, and applies for a patent, only to find that the same idea had occurred to thousands before him, and that patents have been granted on crank-churns of every conceivable form.

Our library takes the place of the patent-examiner. And when the trained investigator desires to follow any particular line of research, his first step is to find out what others have done before him; his second, to consider whether known methods and instruments will answer his purpose, and, if not, to devise and test such methods of research as occur to him.

With this brief introduction, permit me to proceed with the special subject upon which I am to address you.

Leeuwenhoek, the father of microscopy, first discovered the minute organisms known as bacteria in putrid water and in tartar from the teeth; but it was not until the present century was well advanced that the true character of these micro-organisms, and the important part which they play in the economy of nature, were recognized. We know now, that although certain species are pathogenic for man and the lower animals, and give rise to fatal infectious maladies, the bacteria as a class are essential for the continued existence of the higher plants and animals upon the surface of the globe and in the waters of the ocean. It is their function to return to the earth and the air those elements and simple compounds which go to make up the complex organic structures which enter into the composition of the tissues of living plants and animals. So soon as the physiological processes upon which vitality depends have ceased, either from external or internal causes interfering with the integrity of organs essential to life, these universa destroyers commence their work, and those putrefactive changes are inaugurated which result in the disintegration of animal and vegetable tissues. It is evident, that, if no such disintegrating agency existed, the surface of the earth and the waters of the ocean would soon be encumbered with dead plants and animals, and the course of animate nature would be arrested, both by occupation of available space and by exhaustion of nutritive material.

These processes of decay, which in animal bodies exposed to the air occur so promptly, under favorable conditions as to temperature and moisture, are going on continuously in the upper layers of the soil, where the roots of annual plants, and the organic material turned under by the plough of the farmer, must be reconverted into elementary substances which can be appropriated by growing plants. In the ocean the same thing occurs, — the myriads of fish and other living creatures which perish every day are quickly invaded by these omnipresent micro-organisms, and undergo disintegration.

The question may be asked, 'What, then, becomes of these putrefactive organisms, and what prevents them from taking full possession of the waters of the deep?' Like other living organisms, they have their life-cycle, and perish at the end of a given period, and, like other living organisms, their multiplication is limited by the amount of available material. Moreover, they serve as food for a multitude of micro-organisms a little higher in the scale of existence, and especially for the *Infusoria*.

Under this name — *Infusoria* — the older naturalists included all of the minute unicellular organisms observed by them in putrefying infusions. At present this name is applied only to unicellular animal organisms, and among the unicellular vegetable organisms the bacteria have been differentiated from the *Palmellaceæ*, the *Saccharomycetes*, and the reproductive elements of the higher *Algæ*, all of which were formerly confounded under the general name of *Infusoria*.

Ehrenberg (1838) was the first to separate the bacteria as a distinct class of organisms, under the name *Vibrioniens*; but he did not include the spherical bacteria — micrococci — in this class, and did not recognize the vegetable nature of these micro-organisms. In his family of *Vibrioniens* he included four genera, which he defined as follows: 1. *Bacterium* (filaments linear and inflexible); 2. *Vibrio* (filaments linear, snake-like, flexible); 3. *Spirillum* (filaments spiral, inflexible); 4. *Spirochæte* (filaments spiral, flexible).

Dujardin (1841), in his 'Histoire Naturelle des Zoophytes,' still preserved the family of *Vibrioniens* of Ehrenberg among the *Infusoria*, and it was not until 1859 that the eminent French physician Davaine clearly recognized the bacteria as vegetable organisms nearly allied to the *Algæ*, — a view which was subsequently adopted by the distinguished German botanist Cohn, and which is pretty generally accepted at the present day. Some botanists, however, insist upon the affinities of the bacteria with the microscopic fungi, and it is this view which has induced Nägeli to describe them under the name of *Schizomycetes*, or fission fungi. The chief ground for this classification is found in the fact that the bacteria, like the *Mucorini*, are destitute of chlorophyl.

The vegetable nature of yeast-cells had previously (1836) been recognized by Cagniard-Latour and by Schwann; and the vitalistic theory, as regards the alcoholic fermentation, was clearly defined and established experimentally by the last-mentioned author in 1837. This theory was subsequently extended by Pasteur to processes of fermentation and putrefaction in general; and, in the face of much conservative opposition, the distinguished French *savant* finally demonstrated that in the absence of these living ferments organic liquids may be kept indefinitely without undergoing change; and that contact with the atmosphere does not induce these changes, as had been generally supposed, but that when they follow such contact it is due to the presence in suspension of living micro-organisms.

Hoffmann (1843) had previously shown that calcined air admitted to a boiled organic liquid does not cause putrefaction, and in 1854 Schroeder and Von Dusch showed that the suspended particles in the atmosphere may be removed by passing air through a cotton-wool filter.

For a time the advocates of abiogenesis supposed that they had

demonstrated by experiment that micro-organisms may develop in an organic liquid sterilized by heat; but Pasteur showed that the boiling temperature does not destroy all germs, and that to insure sterilization of a neutral or alkaline medium a temperature of 110° to 112° C. is required. The same *savant* first recognized the fact that this failure to sterilize organic liquids by boiling at the ordinary barometric pressure was due to the presence of reproductive bodies, which he described under the name of 'brilliant corpuscles,' 'germs,' 'conidia,' etc. These spores had previously been seen by Perty in 1852 and by Charles Robin in 1853, but it was not until 1876 that their mode of formation and true function were definitely established by the German botanist Cohn. In the same year Koch published in Cohn's *Beiträge zur Biologie der Pflanzen* his admirable memoir, 'Die Aetiologie des Milzbrandkrankheits,' in which he showed that endogenous spores are produced, under certain circumstances, by the anthrax bacillus, and that these are true reproductive bodies. In 1881 the same author published in the *Mittheilungen aus dem Kaiserlichen Gesundheitsamte* his disinfection experiments, in which these spores served as the test of the disinfecting power of heat and of various chemical agents. These experiments showed that dry heat was very much inferior to moist heat for the destruction of these bodies, and that when perfectly dry they resisted for several hours a temperature of 20° C. above the boiling-point. To insure their destruction, a temperature of 140° C., maintained for at least an hour, was found to be necessary. When, however, the spores were immersed in boiling water, or in steam given off from the same at the ordinary pressure of the atmosphere, it was found that a few minutes sufficed to destroy the vitality of these spores.

The demonstration that the atmosphere constantly contains in suspension the living ferments which cause putrefactive and fermentative changes in organic liquids led to the belief, still entertained by many who are not familiar with our bacteriological methods, that the slightest exposure must insure the entrance into such a liquid of these ubiquitous germs.

Pasteur first showed that the liability to contamination by a brief exposure to the air is by no means so great as had been generally supposed, and that, as a matter of fact, a putrescible liquid rarely becomes infected by such exposure as occurs in the ordinary laboratory operation of removing the cotton air-filter for the purpose of inoculating a culture. This is now a matter of every-day laboratory experience; and the fact, also demonstrated by Pasteur, that upon the surface of objects, and especially in accumulations of dust, these living ferments abound in great numbers, is now generally recognized.

Up to the time of Cohn, botanists had paid but little attention to the minute vegetable organisms under consideration; and but for the discovery that some of them invade the human body as parasites, and thus give rise to fatal forms of infectious disease, it is probable that we would still be ignorant of their real characters. The earlier botanists had no conception of the great number of species existing, — species which we now know are in many instances as well defined, and apparently as permanent in their characters, as is the case with plants higher in the scale of living things. The older botanists generally adopted the view that these low organisms are polymorphous, and that there are but a small number of distinct species. Indeed, until the illustrious German bacteriologist and physician gave us a reliable method for isolating the various forms which are commonly associated in putrefying infusions, it was impossible to determine what relation the little spheres, rods, and spiral filaments revealed by the microscope might bear to each other. Since Koch's methods have been employed by industrious investigators in all parts of the world, we have commenced to learn something of the bacterial flora; and it is apparent that the number of distinct species is enormous, — comparable, for example, with the number of well-defined species of diatoms, desmids, or other classes of *Algæ* higher in the scale. This flora is no doubt different in different parts of the world, although some species are widely distributed, and we may expect to discover many new forms when bacteriologists extend their researches to distant portions of the globe, and especially in the tropics. Already extended researches have been made, especially in Germany, with reference to the bacterial flora of the soil, of streams and wells, and of the atmosphere; but this line of research may be said to be still in its infancy, and what has been done only serves to indicate the extent of the field and the amount of work which remains to be done before our knowledge will be complete. The same may be said of the bacterial flora of the intestine of man and of the lower animals. Here we have not only to determine the constant species, as distinguished from the accidental, and in some cases no doubt pathogenic forms, but we have also to determine the physiological *rôle* of each constant form; for we can scarcely doubt that these commensals of man, which help to disintegrate the organic pabulum introduced into the alimentary canal, and give rise to the formation of a variety of chemical products, some of which are known to be toxic, play an important part in the economy of the individual.

With the methods now at our command, these questions, and those relating to the physiological characters of pathogenic species, are open to investigation. But let me warn the young bacteriologists of to-day not to plume themselves too much upon the scientific achievements which await them in the application of these methods, and to remember that the serious errors which in the past have been made by many of the pioneers in this field of investigation were in many instances due, not to an inferior degree of intelligence or a less earnest desire to get at the exact truth, but to the difficulties which they encountered in a new field of investigation, in which satisfactory methods of research were not yet developed.

The great impetus which bacteriological studies have received since the introduction of Koch's plate-method and the use of solid culture-media, is shown by the recent literature of the subject. Prior to this date (1881) the number of active workers in the field was small, and much of the work done had little scientific value from our present point of view. Morphological differences were the chief reliance for differentiating species, but we now know that such distinctions are entirely unreliable. Many species which have important and permanent physiological characters, which serve to distinguish them in a definite manner, are practically identical in their morphology. Thus, for example, no bacteriologist would attempt to decide, by a microscopical examination alone, whether a coccus obtained from the pus of an acute abscess was the staphylococcus aureus, citreus, or albus; but the growth upon a solid culture-medium would decide the matter by the characteristic color of the mass developed about the point of inoculation. A great part of the work to be done in bacteriological laboratories consists in this differentiation of species, and in defining in an exact manner the biological characters of each, including mode of growth in various media, resistance to chemical agents and to heat and cold, pathogenic power, etc.

As indicating the progress in this department of science and the character of the work already done, I propose to make a brief analysis of the literature of the subject. In a bibliography at hand, which is quite full without being complete, I find reference to 41 papers published prior to the year 1860. Of these, 7 are in German, 31 in French, and 3 in English. During the decade from 1860 to 1870 the same bibliography gives the titles of 55 papers, of which 8 are in German, 43 in French, 3 in Italian, and 1 in English. The following decade, 1870 to 1880, shows a very greatly increased activity in this field of research; and among the titles given we have in Germany papers by Buchner, Billroth, Cohn, Eberth, Frisch, Hiller, Klebs, Koch, Letzerich, Nägeli, Orth, Pragmowski, Weigert, Wernich, and others. In France the most prominent names during this period are those of Arloing, Cornevin, and Thomas, Béchamp, Paul Bert, Bouley, Chauveau, Colin, Davaine, Donné, Felz, Miquel, Pasteur, Van Tieghem, and Toussaint. In England the most important contributions during the same period were by Bastian, Beck, Cunningham, Dallinger, Dougall, Klein, Lewis, Lister, and Sanderson. The total number of titles included in my bibliography is 329, of which 122 are German, 121 French, 57 English, and 9 Italian. From this time the interest in this field of investigation, as shown by the literature in which experimental investigations are recorded, has very rapidly increased. My bibliography gives the titles of 92 papers published during the year 1881, of which 27 are in German, 45 in French, 16 in English, and 4 in Italian.

Passing over the years 1882, 1883, and 1884, I take from the valuable 'Jahresbericht' of Baumgarten, first published in 1885,

the following figures, which, for convenience, I have arranged in tabular form: —

TITLES OF PAPERS RELATING TO BACTERIOLOGY.

Year.	German.	French.	Italian.	English.
1885	119	19	5	5
1886	291	58	44	23
1887	483	124	66	55

No doubt the great increase in the number of papers during the year 1887 is in part due to the fact that the bibliography is more complete, and many papers of minor importance are included. It must be remembered, also, that quite a number of the Italian bacteriologists, and some of the students from this country who have pursued their bacteriological studies in Germany, publish their papers in the German language.

It will be seen from what has been said, that while the French took the lead in researches in this department prior to 1870, and during the following decade (1870–80) contributed about the same number of memoirs recording experimental work as the Germans, the last-mentioned nation is now far ahead not only as regards the number of workers in the field, but, I may add, in the scientific value of the work done; while the number of workers in this field of investigation is even less among English-speaking people than among the Italians. I am not willing to admit that this difference is due to race characteristics alone, although the Germans are noted for the thorough way in which they devote themselves to the elucidation of scientific questions by the experimental method. The great activity in France during the period included between the years 1860 and 1880 was without doubt largely due to the influence of Pasteur, who, by his experimental work and his writings, did more than any other man to establish the fact that the minute organisms, which prior to his time had received so little consideration, are important factors in the economy of nature.

In the ante-Koch epoch there was no name in Germany to compare with that of the illustrious French *savant*; and if, from our present point of view, we can point to certain errors of inference, due to the imperfect development of bacteriological technique, these cannot be held to constitute a serious blemish upon the brilliant scientific record of Pasteur. Where are the pioneers who have never followed a false trail? The true distinction of the man of science is that he renounces his own errors as soon as he is convinced that he has made one.

Among the pioneers in bacteriological researches in France, there is one who, next to Pasteur, is entitled to special consideration. I refer to the distinguished physician and scientist, Davaine, whose first paper upon the anthrax bacillus was published in the *Comptes Rendus* of the French Academy in 1863. Certainly the work of Davaine, of Chauveau, and of Toussaint may be compared favorably with that of the German physicians, who contributed most largely to the literature of our subject before the time of Koch.

The discovery by Obermeier, in 1873, of the spirillum of relapsing fever was a notable event in the history of bacteriology, and at once attracted the attention of physicians in all parts of the world to this class of micro-organisms; and it is to physicians, rather than to the botanists, that we owe the rapid development of our knowledge of these minute plants.

A great impetus was given to bacteriological studies in Germany by the introduction by Weigert (1877) of the aniline dyes for staining these micro-organisms.

Koch, in referring to this new method in a paper published a few months after Weigert's first publication regarding it, says that "the aniline colors are retained by micro-organisms with such intensity and with such rapidity, that we may consider these colors re-agents for distinguishing the bacteria from crystalline deposits, or amorphous material of any kind, from fat drops or other corpuscles of small dimensions." From this time these dyes have been our main reliance for differentiating the bacteria from organic and inorganic granules which often resemble them closely in form, and for demonstrating their presence as parasites, in the blood and tissues of animals, in the infectious maladies.

Dr. Robert Koch, who is now generally recognized as the foremost bacteriologist of the world, published his first papers during the years 1876 and 1878, in Cohn's *Beiträge zur Biologie der Pflanzen*. In 1878 his 'Untersuchungen ueber die Aetiologie der Wundinfectionskrankheiten' appeared. These publications marked him at once as a master in experimental investigations, and as a most careful and reliable observer.

Schroeter, in 1872, had made use of slices of boiled potato for the cultivation of chromogenic bacteria, but the method of cultivation in solid media was first described by Koch in Vol. I. of the *Mittheilungen aus dem Kaiserlichen Gesundheitsamte*, published in 1881. This method, together with his plate-method of isolating bacteria, is the foundation-stone upon which the bacteriology of the present day has established itself; and since the road has been pointed out numerous workers in all parts of the world have hastened to explore the previously unknown mines of truth in this important and attractive department of biology.

There are to-day bacteriological laboratories not only in many of the large cities of Europe, from Russia to Spain, but also in a number of the principal cities on this side of the Atlantic. During my recent visit to the City of Mexico, I found a complete equipment of Koch's culture apparatus, and of the apochromatic objectives of Zeiss, in the laboratory of Dr. Carmona y Valle, and in Havana a similar outfit in the laboratory of the 'Cronica Medica,' under the direction of Dr. Santos Fernandes.

The rapid progress of bacteriology in Germany has been due not alone to the epoch-making achievements of Koch, but also, to a very considerable extent, to the enlightened policy of the government. Koch was called to Berlin as soon as his merit was recognized, and his work was carried on in the laboratories of the Imperial Board of Health, where he had the assistance of those medical officers of the German army whose names stand only second to his in the record of valuable work done in this department of science. I refer, of course, to Loeffler, to Gaffky, and to Wolffhügel; and to these associates in his earlier researches may be added the names of Plagge and of Weisser, who have been with him in his new laboratory.

If during the past ten years we had also had a well-equipped laboratory, under proper direction, at the seat of government, does any one doubt that men could have been found in the medical corps of the army and of the navy who would have done work in this department of scientific research which would have been creditable to us as a nation?

Certainly it is not creditable that we, as a nation, have contributed so little to the progress of knowledge in this direction. Let us hope, however, that we are entering upon a new era. Here in Brooklyn private munificence has provided the means of research which the national government should have provided long since; and here, at least, the fault will rest with the profession, if active workers are not found to avail themselves of the facilities provided for making original researches in bacteriology, in physiology, and in experimental pathology.

Another important landmark in the progress of bacteriology and of scientific medicine is the discovery of the tubercle bacillus, and the demonstration that it is the specific etiological factor in the causation of tuberculosis. As you well know, we are also indebted to Koch for this discovery, which was first announced in the *Berliner klinische Wochenschrift* in 1882.

[Having referred briefly to some of the principal facts relating to the history of the subject, Dr. Sternberg occupied the remainder of the time during the lecture in giving an account of the morphology of micro-organisms.]

PROF. WILLIAM H. PICKERING has succeeded in detecting a number of new nebulæ by means of photography. The region surrounding the nebula of Orion was selected for these experiments, and from the results the author concludes, that, by photographing the entire sky, four or five thousand such objects may be discovered. Only in case the large nebula of Orion should prove to embrace all the new nebulæ in its limits, this proportion would not hold good. The experiments show, however, that the method is well adapted to verifying and completing our catalogues of stars.